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14. ABSTRACT
This project focused on design of adaptive transmission methods enabled by the long range fading prediction (LRP) for several mobile radio systems.
First, a new improved allocation algorithm was proposed for multicarrier code-division multiple access (MC-CDMA) system with adaptive frequency hopping. When combined with multiuser detection, the proposed system is very efficient in mitigating the fading and multi-access interference for realistic mobile radio channels

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Adaptive Transmission, Wireless Communications, Frequency Hopping, Channel Modeling, Multicarrier Code-Division Multiple Access, Adaptive Coded Modulation, Fading Prediction

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Statement of the problem studied.

This project focused on design of adaptive transmission methods enabled by the long range fading prediction (LRP) for several mobile radio systems.

Summary of the most important results.

- Multicarrier code-division multiple access (MC-CDMA) system with adaptive frequency hopping (AFH) has attracted attention of researchers due to its excellent spectral efficiency. A suboptimal water-filling (WF) channel allocation algorithm was previously proposed for the reverse link of this system. To overcome the limitations of the WF algorithm in the presence of fading-induced near-far problem, a new allocation algorithm was proposed in this project and demonstrated to improve performance when the conventional matched filter (MF) receiver is employed. Moreover, the allocation methods were extended to accommodate multiuser detectors (MUDs) at the receiver for MC-CDMA system with AFH. It was demonstrated that the combination of the improved allocation algorithm and the linear MUDs is very efficient in mitigating the fading and multi-access interference (MAI) for realistic mobile radio channels with correlated subcarriers, channel state information (CSI) mismatch, and imperfect power control. Numerical results show that the proposed adaptive transmission method has much greater system capacity than conventional non-adaptive MC direct-sequence (DS)-CDMA system.

- We have demonstrated previously that LRP enables adaptive transmission methods for rapidly varying mobile radio channels when the additive noise is low. In this project, a novel data-aided noise reduction method was proposed to enhance the accuracy of fading prediction in adaptive modulation systems for realistic SNR values. The proposed method includes an adaptive pilot transmission mechanism, robust noise reduction, and decision-directed channel estimation. Due to improved prediction accuracy and low pilot rates, the data-aided noise reduction results in higher spectral efficiency than previously proposed noise reduction techniques, which rely on oversampled pilots.

- Since adaptive coded modulation (ACM) is more sensitive to prediction errors than uncoded adaptive modulation, noise reduction is necessary to maintain the coding gain for realistic SNR and prediction ranges. Despite reduced prediction accuracy caused by per-survivor processing, it was demonstrated that ACM enabled by LRP with data-aided noise reduction provides significant coding gain for short prediction ranges often employed in practice.

- The physical model was enhanced by allowing the reflectors and the transmitter to move to reflect the peer-to-peer system more accurately. Moreover, antenna directionality was modeled to facilitate the investigation of prediction for antenna arrays and sectored antenna systems. In addition, we observed that the physical model data set is easier to predict than the Jakes model for most low-to-medium SNR values, while the opposite conclusion was

reached in our previous research for high pilot SNR ≥ 30dB. This can be explained as follows: for lower SNR, noise dominates prediction performance, and the prediction is aided by lower number and non-uniform distribution of reflectors in the realistic physical model data set. On the other hand, for high pilot SNR, nonstationarity of fading coefficient dominates prediction errors and limits the accuracy of prediction for the physical model relative to the Jakes model.

- Adaptive bit-interleaved coded modulation (ABICM) is attractive for rapidly varying mobile radio channels due to its robustness to imperfect channel state information (CSI) at the transmitter. Novel ABCIM method based on the expurgated bound was proposed. This method improves upon previously investigated ABICM techniques since it is able to maintain the target bit error rate for diverse CSI conditions. Spectral efficiencies of the proposed ABICM method, adaptive trellis-coded modulation, and uncoded adaptive modulation are compared for an adaptive mobile radio orthogonal frequency division-multiplex (OFDM) system aided by the long-range fading prediction. It is demonstrated that ABICM is much less sensitive to prediction errors than the other two adaptive modulation techniques, which do not employ interleaving, but reliable fading prediction is still necessary to achieve high spectral efficiency of ABICM for practical channel conditions.